

# Energy Related Capabilities and Projects

**A**s a U.S. Department of Energy multiprogram national laboratory, the Idaho National Laboratory (INL) employs 1,200 specialized scientists and engineers to bring about R&D discoveries for nuclear, fossil and renewable energy technologies — including the production of hydrogen — to deliver and secure sustainable energy sources and increase environmental quality for the nation.

## **HYDROGEN**

INL's Hydrogen Initiative addresses critical scientific and engineering issues to realize the benefits of a hydrogen economy.

To address this historic priority it focuses on hydrogen production, separation, storage and use.

### **Hydrogen from Nuclear Energy**

INL performs a major role in R&D for the production of hydrogen using nuclear energy. The advantages of using nuclear energy for hydrogen production include near zero CO<sub>2</sub> emissions and independence from fossil fuels. Two promising methods for using nuclear energy for hydrogen production include high-temperature electrolysis and thermochemical cycles for splitting water into hydrogen and oxygen. A new Very High Temperature Reactor is under consideration for this purpose.

### **Hydrogen from Diesel Fuel**

INL is participating with SOFCo EFS in its 500 kW Integrated Fuel Processor (IFP) Program as part of the U.S. Navy Ship Service Fuel Cell Program. INL is tasked to design, fabricate, and test a first generation IFP for producing hydrogen-rich gas from NATO-F76 diesel fuel. The IFP produces and purifies hydrogen for fuel cell applica-

tions. The process uses autothermal reforming technologies to provide hydrogen fuel for clean fuel cell electric power on Navy ships. The IFP and associated fuel cell allows significantly more energy to be generated from lower-grade fuels than could be realized from combustion alone.

### **Hydrogen, Electricity from Coal**

INL is developing multiple technologies to support clean coal gasification processors, combustion emissions reduction technologies for heavy metals, SO<sub>x</sub>, NO<sub>x</sub>, and CO<sub>2</sub> capture for geologic sequestration.

### **Hydrogen Processing and Storage Technology**

INL and its industrial partners are working to develop a unique composite membrane structure of hydrogen and oxygen at high temperatures. INL is also studying other unique inorganic polymer molecular composites for hydrogen storage and separation applications and these materials exhibit exceptionally high selectivity for hydrogen and all other gasses. INL is studying processes to regenerate sodium borohydride from spent sodium borate. (See also Transportation: Fueling Infrastructure, on page 3.)

## **BIOENERGY**

INL's Bioenergy Initiative embraces the vision of "Whole Crop Utilization" and leverages key multidisciplinary INL capabilities to address the major science and technology needs associated with the cost-effective utilization of waste biomass. Whole Crop Utilization means using the entire crop, including the grain and traditionally discarded plant biomass to produce food, feed, fiber, energy and value-added products. Besides promoting use of agricultural biomass to produce energy, fuels, chemicals and durable goods, the Whole Crop Utilization concept has the added advantage of revitalizing rural economies by providing an additional revenue source to growers.

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*An artist's rendering of the Very High Temperature Reactor that could produce hydrogen (above); and the diesel reformer that converts diesel fuel into hydrogen that passes through a fuel cell to generate electrical current (below).*



Science

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INL is a member of DOE's National Bioenergy Center and has lead responsibility for biomass feedstock harvesting R&D.



*INL scientists and engineers are researching ways to harvest biomass feedstock and prepare it for a biorefinery.*

## RENEWABLE ENERGY

### Wind

INL provides technical support to the DOE's Wind Powering America Program — an outreach initiative to foster awareness of the benefits and applications of wind energy and to promote the development of domestic wind energy resources. As part of this effort — and in cooperation with the Idaho Department of Water Resources Energy Division — INL installs anemometers on state and private lands, evaluates wind data, and assists stakeholders in wind energy deployments through the Idaho Wind Working Group and public workshops. INL also performs wind energy assessments as well as wind energy systems engineering and deployment activities for the Department of Defense to provide clean, low cost renewable energy at military installations.

### Geothermal

INL is the lead laboratory in geosciences for DOE's Geothermal Program. The mission of this program is to work in

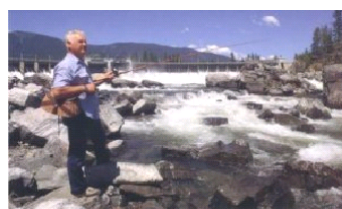
partnership with U.S. industry to establish geothermal energy as a competitive contributor to the domestic energy supply. The program has three focus areas: Geoscience, Exploration and Drilling, and Energy Systems Research and Testing. INL performs work in all three focus areas that includes resource identification, assessment and development, resource expansion (Enhanced Geothermal Systems), resource productivity and sustainability, and energy conversion. It also participates in GeoPowering the West — an outreach activity that fosters awareness of the availability and benefits of geothermal energy — and promotes its development in the Western United States.



*The INL works with DOD to install wind turbines on Ascension Island.*

### Hydropower

INL is the lead laboratory for engineering support for DOE's Hydropower program. The mission of this Program is to improve the technical, societal, and environmental benefits of hydropower by conducting and coordinating research and development with industry and other federal agencies. The primary focus of the program is the development of the next generation of hydropower turbine technology through the Advanced Hydropower Turbine System Program. INL also performs work on hydropower



*Engineers are studying the available water energy potential in stream segments around the country.*

resource assessment, hydropower economics, and integration of hydropower with other energy systems.

### Power Technologies/ System Integration

INL performs power systems research and engineering for renewable energy and other energy sources for both the DOE and DOD. Research and applications work is performed in areas including power system integration, reliability, power quality, power plant control, hybrid power applications, distributed power, standards development and sensors.

## FOSSIL ENERGY

INL pioneers innovative research and development activities to reduce U.S. petroleum imports, increase the use of cleaner burning natural gas, solve environmental dilemmas and reduce industry operating costs. It commercializes quality products and services; develops exploration, production and gas and oil processing technologies; and develops and tests natural gas vehicles. It also develops technologies in support of a hydrogen economy infrastructure, expands the use of ultra-clean fuels and researches methods and sites for carbon sequestration.

### Natural Gas, CNG, LNG and H<sub>2</sub> Blends

The INL Alternative Fuels Program focuses on liquefied natural gas (LNG) and compressed natural gas (CNG) as alternatives to conventional gasoline and diesel fuels for powering heavy-duty and light-duty vehicles. The program is part of the DOE's initiative to reduce air pollution and reduce the nation's dependence on imported petroleum products by promoting the use of domestically available fuels that burn with lower emissions. LNG and CNG meet these criteria, and provide the additional advantages of being relatively safe to store and use and are cost-competitive with conventional fuels.



*INL and a private utility partner established this LNG liquefaction plant in Sacramento, CA.*

### Fueling Stations and Infrastructure

INL's hydrogen research draws on core competence in several engineering and technology areas, including systems engineering, safety and risk



*INL leads the testing and monitoring activity of advanced alternative-fueled vehicles.*



assessment, chemical and mechanical engineering, manufacturing and materials, sensors and controls, plasma processing, fuel cell technology, biotechnology engineering, and alternative fuel vehicle fueling infrastructure development. It pursues development and commercialization of technologies related to production, infrastructure, and use of hydrogen fuel.

#### ***Oil, Gas Production/Use***

INL provides solutions to industry-identified problems ranging from downhole instrumentation to pipeline production and transportation. Projects include research on a downhole seismic source for look-ahead prediction, a high void fraction multiphase meter, a large downhole seismic sensor array, locating geopressured hydrocarbon reservoirs, oil and gas production sensors and controls, single well seismic imaging, and transportation of hydrocarbon indicators. The Laboratory develops technologies to sequester CO<sub>2</sub> and understand its fate and transport in the subsurface. INL also develops simple low-cost bioreactors to remove sulfides from produced water and gas in oil field and offshore platform environments.

#### ***ENERGY STORAGE***

##### ***Advanced Battery Test Laboratory***

INL's Energy Storage and Conversion Program principally supports the U.S. Department of Energy's FreedomCAR and Vehicle Technologies Program Office. The Program has the lead role for developing, characterizing, testing and evaluating all DOE high-power energy storage devices for electric vehicle (EV) and hybrid electric

vehicle (HEV) applications. These devices include advanced batteries, ultra capacitors, and flywheels.

The Program also supports the FreedomCAR partnership — comprised of DOE, and U.S. automakers Ford, General Motors, and Daimler Chrysler — by participating on the partnership's FreedomCAR Electrochemical Energy Storage and the Systems Analysis technical teams. This INL Program is the DOE's lead laboratory for all HEV advanced energy storage testing — including the development of test protocols, procedures and manuals, and analytical methodologies. It also conducts performance testing, analyses, life modeling and prepares special product characteristics reports.

#### ***TRANSPORTATION***

##### ***Fueling Infrastructure***

INL manages the light-duty vehicle testing activities of the DOE's Energy's Advanced Vehicle Testing Activity (AVTA). As part of this activity, INL and AVTA teamed with Electric Transportation Applications and Arizona Public Service (APS) to develop the Alternative Fuel Pilot Plant that produces and dispenses hydrogen on site. The hydrogen is produced through electrolysis

by operating a PEM fuel cell in reverse. This plant also compresses natural gas on site and fuels internal combustion engine test vehicles that operate on 100% hydrogen and blends of 15% to 50% hydrogen and compressed natural gas.

##### ***Heavy Vehicles***

INL works with heavy-duty diesel engine manufacturer Detroit Diesel to explore the use of liquefied natural gas applications in INL's bus fleet. This partnership has resulted in the conversion of seven INL diesel buses to LNG and has advanced the commercial use of natural gas technology for transportation purposes.

##### ***Oil Bypass Filter Technology***

INL is conducting an oil filter bypass demonstration project with eight of its diesel motor coaches to determine the extent that engine oil usage can be reduced. The buses have accumulated well over 200,000 test miles and their engine oil is regularly sampled for 26 additives and contaminants that contribute to the volume of hazardous waste.

#### ***ENERGY CONSERVATION Sustainable Building Design***

INL is providing research and support to the DOE and other agencies to develop standards and technologies for sustainable design of buildings. "Sustainable Buildings" is the industry term for "green" building design, construction, operation, and disposition. Sustainable design includes siting, water efficiency, energy, materials, and indoor environment considerations. INL key capabilities include building energy use evaluation, research



***INL tests and monitors alternative-fueled vehicles for energy and environmental performance.***

Science



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in sustainable heating and cooling of buildings, and development of sustainable design programs.

## **INDUSTRIAL AND MATERIAL TECHNOLOGIES**

INL supports the DOE Industrial Technologies Program to enhance the nation's industrial competitiveness, productivity and energy efficiency — and it performs R&D through Industries of the Future Program that focuses on the nation's aluminum, chemical, forest product, glass, metalcasting, mining and steel industries.

### **Metals Joining**

INL has a long history of providing state-of-the-art science and technology for joining both reactor and industrial materials. It conducts R&D in the areas of intelligent machines, intelligent sensors and controls, prototype machine design and fabrication, advanced computational methods, materials processing and procedure development, weld integrity evaluation, non-destructive evaluation. INL has equipment and facilities for gas metal arc welding, gas tungsten-arc welding, submerged arc welding, laser welding, hybrid laser-assisted arc welding, friction stir welding, resistance spot welding, gleeble testing, and robotic welding cell development. In addition, it has experience in welding carbon steel, stainless steel, and nickel-based, titanium, aluminum and oxide dispersion strengthened alloys.

### **Plasma Processing**

INL is devoted to applying plasma science to the development of unique industrial technologies including the extraction of metals from ores, the synthesis of advanced metal alloys and ceramics, the development of advanced coating/forming processes, and similar plasma-related processes to enhance the competitiveness of U.S. industry in world markets. The group has equipment and facilities for the synthesis of nano-size powders; development for hydrogen carriers and chemical synthesis; plasma spraying of advanced materials, design and fabrication of hybrid plasma systems, plasma processing of natural gas for liquid conversion and heavy oil upgrade; waste form development for nuclear waste stabilization; and solid state combustion synthesis and net-shape forming of cermet materials.

### **Spray processing**

INL focuses on the development of applications for spray forming technology. Spray forming is a patented rapid solidification process (RSP) technology involving gas-assisted atomization of metals and alloys followed by deposition on a substrate to form coatings or near-net shape solids. It addresses a broad range of applications including molds and dies, flat rolled products, cylindrical and tubular products, coatings and claddings, and membranes. By combining rapid solidification with near net-shape materials processing, spray forming can offer advantages in processing, material properties, cost, and energy savings over conventional approaches.



***Spray processing was used to develop INL RSP Tooling technology, which won an R&D 100 award, a DOE Energy@23 Award and a Federal Laboratory Consortium Award.***

### **For more information**

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INL is a U.S. Department of Energy national laboratory operated by Battelle Energy Alliance

